North Carolina State University
Department of Civil Engineering

FUNCTIONAL DEPLOYMENT PROTOCOL FOR THE WELL INJECTION DEPTH EXTRACTION (WIDE) SYSTEM at the Battelle West Jefferson Filter Bed

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J. D. Quaranta, Ph.D., P.E.
Research Assistant Professor

M.A. Gabr, Ph.D., P.E.
Professor

T. Kunberger, EIT
Research Assistant

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NCSU-00 / September 2002	
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NCSU-03 / December 2002	**Title Page** **Incorporated Sequence 1, Cycle 2 – Pressurized Injection Test Plan pages 17 - 22**
NCSU-04 / January 2003	**Appendix A: Seq 1: Cycle 2&3 Commissioning Program**
NCSU-05/February 2003	**Extraction Plan Preparation**

1.0 BACKGROUND

The objective of this project is to deploy the Well Injection, Depth Extraction (WIDE) technology for soil flushing of radioactive contaminants at the Battelle Columbus Laboratories Decommissioning Project (BCLDP) West Jefferson North (WJN) facility (JN-1 Abandoned Filter Bed). This project is a single deployment for the *in situ* removal of Cesium^{137}. The flushing methodology will utilize both water and a co-solvent to enhance desorption. The project goal is to assist Battelle to radiologically release the site for unrestricted use without disturbing the surroundings.

2.0 OBJECTIVES OF THE FUNCTIONAL TESTS

In order to implement operation of the WIDE system at the Battelle site, functional testing of the system must be performed prior to identifying optimum operational parameters. The functional tests will be broken down into four sequences. Each individual sequence test will address a specific area of WIDE operation. Results of these test willassure system operability and aid in the selection of parameters needed for process control and operations.

SEQUENCE 1: INJECTION ONLY OPERATION

The objective of the Injection Testing Sequence is to determine operational parameters to operate the WIDE system at designed injection flowrates and pressure needed to obtain soil saturation capacity, sustained saturation, and maintainable peizometric levels to support subsequent soil flushing using concurrent injection/extraction operations. This test sequence will determine the water injection flow-rates and injection system pressure necessary to accomplish recharge of the groundwater table without damaging the soil physical structure. For all injection operations potable water will be used. This sequence will be divided into three test cycles having the following objectives.

Cycle 1:

This injection operation will commence on a limited scale using one quarter of the PVWs installed in Plot 2. Liquid injection will be accomplished via a "Falling-Head" technique. This approach involves the injection of water to be made by gravity feed.

Cycle 2

This Cycle of tests will be performed on the same ¼ scale as Cycle 1 with a variation in the liquid delivery system. Here a positive displacement pump will be used to deliver a varying flowrate of water. The water injection flowrate will be established at a corresponding injection pressure.

Cycle 3

This testing cycle will expand upon the scope of Cycle 2 testing. Here, scale-up information from Cycle 2 will be used to provide design parameters as the injection area is expanded from a limited ¼ scale Plot to encompass all injection PVWs in Plot 2. All testing in this cycle will be limited to Plot 2. Injection flowrates will be measured under a positive pumping regime.

SEQUENCE 2 EXTRACTION ONLY TESTING

Similar to the Injection Only Sequence, The Extraction Only Sequence will be approached in two testing cycles. The objectives of the tests are to calibrate the WIDE system under various vacuum extraction modes of operation. Operational data targeted includes: extraction air flow (Q_{eA}), vacuum system pressure (P_{vac}), and vacuum depths will be varied in order to achieve stable and predictable groundwater extraction flow-rates (Q_{eW}) and volumes. Influences on the groundwater drawdown will be observed. Sequence 2 will comprise two testing cycle components; Cycle 1 and Cycle 2.

Cycle 1:
This testing will target Plot #2's reduced one-quarter area. Applied vacuum pressures will be evaluated against groundwater extraction and natural groundwater recharge. Operational information such as on-off routines for the extraction system to coincide with natural groundwater recharge will be identified.

Cycle 2:
This testing will scale up to the full Plot 2 injection area. Data obtained from the limited Cycle 1 tests will be used to for gaging the scale-up to the full operating area.

SEQUENCE 3 CONCURRENT INJECTION / EXTRACTION TESTING

This Sequence targets identifying the operational parameters desired for continuous operation of the WIDE system. . In order to run the system in a continuous mode and achieve soil flushing, the groundwater that is extracted must be replaced and displaced between the injection and extraction wells.
Building on the results of Sequence 1 (Cycles 1-3) information pertinent to the injection system was the volume of groundwater required to saturate the subsurface and the associated time scale. In Sequence 2 (Cycles 1 & 2) information will be gained to support the determination of the volume of groundwater that will be removed during the extraction period.

Sequence 3 will advance the identified individual system parameter of Sequences 1 & 2 and meld these into process operational parameters necessary to achieve an injection/extraction flow balance to promote predictable *in situ* soil flushing. Two separate test cycle will be advanced as discussed below:

Cycle 1: This testing will target Plot #2's reduced one-quarter area (15'x 15'). Injection flowrates selected from Sequence 1 will be matched with the vacuum pressures and flowrates from Sequence 2. Volumetric balancing of the injection and extraction of liquid will be performed. Operational information such as on-off routines and staggering operating schedules will be reviewed and identified.

Cycle 2: This cycle will expand the area of Cycle 1 (above) to the full Plot #2 area. This work will bring the full system on-line to first observe performance between predicted operational response to the actual system performance. Once this plot has been run to consistent performance measures the operating parameters will then be used on the remaining eight plot areas. The other plot areas will be operated and the data information will be used to develop a standard WIDE operational plan.

3.3 Operating Variables

In the performance of the functional tests, certain operational parameters will be varied in order accomplish the stated objectives. These parameters along with key process variables that need to be monitored are summarized in the following sections

The following operational parameters will be recorded during all sequences of the project testing.

PARAMETER	FREQUENCY	NOTES
Water injection Falling Head level	Hourly	Tank#2: Hi mark = 877 ft Low mark= 872 ft Tank #3: Hi mark = 876.3 ft Low mark= 871.3 ft Tank #4: Hi mark = 876 ft Low mark = 871 ft
Injection water pressure (pos. pump)	Hourly	Pump gage pressure: Field gage pressure: 0 to 3 psi
Injection water flow rate	Hourly	
Injection water tank level (falling head requires elevation change recording)	Hourly	
Calendar time (time needed to observe changes in groundwater level with time)		
Run time (time needed to saturate subsurface and raise groundwater level)		
Non-Run time (time needed for groundwater to equalize)		
Natural rainfall	Monthly	
Ground water level (using piezometer)	2x daily	
Cs in groundwater	Weekly	
spCond of groundwater	Weekly	Increase denotes dilution
pH of groundwater	Weekly	
BOD	Monthly	
COD	Monthly	
TSS in groundwater	Monthly	Observe PVW textile clogging

3.4 Schedule

Operations work will be performed in an 6-8 hour shift. It may be necessary for some personnel support to exceed 10 hours a day, e.g., HP coverage. Support from Battelle onsite laboratory will be necessary.

4.0 SITE PREPARATION

4.1 Site Layout

Functional testing will be performed with the WIDE system installed at the abandoned filter beds. The drawing, "Enclosure and Equipment Layout" shows the configuration of the major equipment of the extraction system.

4.2 15'X15' Test pad

Groundwater monitoring wells (piezometers) will be installed in order to obtain required data. The wells will be located at certain points within the test area with a total of 48 piezometers to be installed in and around the WIDE Test Pad.

4.3 Infrastructure Support

The test site has 110vac power supplied. Some analytical instrumentation will be utilized at the test site. This instrumentation will require electrical power and shelter from the elements. The analytical instrumentation will be placed in the temporary shelter that was erected to contain the mechanical equipment.

4.4 Equipment connection and valve line-up

Equipment connections and valve line-ups for the functional tests will be specified on the operations manual/checklist. This sheet will indicate the air and water flow settings and the place where the water will be collected and stored for subsequent processing through the 3M system.

4.5 Equipment check out and shakedown

Prior to operation of the system, basic mechanical testing and shakedown will occur. This testing will assure the operation of the system can be accomplished as designed and in a safe manner. This work will involve: Leak Testing; Volume Calibration of Non-graduated Tanks; and Flow Testing/Process Flow Adjustments

4.6 Baseline Sampling

Baseline data will be obtained from review of previous groundwater data from wells and additional sampling for groundwater levels.

7.0 DESCRIPTION OF WIDE OPERATIONS

7.1 Equipment used

Compressor

An Ingersoll-Rand P600WCU, 600 cfm diesel driven.

Extraction Skid

See drawings BCLDP-0004, and BCLDP-0002 sht 1

Cesium Filtration System

See drawing BCLDP-0002 sht 2

Injection System

See drawing BCLDP-0002 sht 3

7.2 Operations Manual/Checklist

For operation of each circuit, a detailed operations manual/checklist describing system operation has been prepared and is attached in appendix A.

7.3 Data Collection

Examples of data collection sheets are included in appendix B.

APPENDIX A: SEQUENCE 1: INJECTION ONLY OPERATION Cycle 1

SEQUENCE 1:INJECTION ONLY OPERATION

The objective of the Injection Testing cycle is to determine operational parameters needed to operate the WIDE system at designed injection flowrates and pressure needed to obtain soil saturation capacity, sustained saturation, and maintainable peizometric levels to support subsequent soil flushing using concurrent injection/extraction operations. For all injection operations potable water will be used.

To accomplish this objective, the testing cycle will be paced in three cycles of operation as follows:

Cycle 1:

This injection operation will commence on a limited scale using one quarter of the PVWs installed in Plot 2. Here, four rows having 8 PVWs each totaling 32 PVWs will be operated. Liquid injection will be accomplished via a "Falling-Head" technique. This approach involves the injection of water to be made by gravity feed. Table 1 lists the input and output data to be evaluated for Cycle 1.

TABLE 1. Cycle 1 Input/Output Data

Collected Data Input	Computed Data Output (Graphical)
Totalized Water Volume Injected	Injection Flowrate vs Run Time (event, cumulative)
Initial Tank # and Water Level (ft)	Injection Gradient vs Run Time (event, cumulative)
Final Tank # and Water Level (ft)	Piezometric Surface Mounding Response vs Time (event, cumulative)
Start Time/End Time/Cumulative Time	
Peizometer Levels	

Cycle 2:

Cycle 2 will be performed on the same 32 PVWs as Cycle 1. This operation will introduce the injected liquid using a pump. The water injection flowrate will be established at a corresponding injection pressure. Table 2. presents the Cycle 2. Input/Output Data.

TABLE 2. Cycle 2 Input/Output Data (1/4 Plot 2 Area)

Collected Data Input	Computed Data Output (Graphical)
Totalized Water Volume Injected Established Steady –state Flow	Injection Flowrate vs Run Time (event, cumulative)
Corresponding Injection Pressure recorded at field manifold.	Injection Gradient vs Run Time (event, cumulative)
Peizometer Levels at Event and Cumulative Time Intervals.	Piezometric Surface Mounding Response vs Time (event, cumulative)
Start Time/End Time/Cumulative Time	Injection Pressure vs Flowrate

Cycle 3:

This testing cycle will expand upon the scope of Cycle 2 testing. Here, scale-up information from Cycle 2 will be used to provide design parameters as the injection area is expanded from a limited ¼ scale Plot to encompass all injection PVWs in Plot 2. All testing in this cycle will be limited to Plot 2. Similar to Cycle 2, the following data presented in Table 3 will be obtained and computed for Cycle 3.

TABLE 3. Cycle 3 Input/Output Data (Full Scale Plot 2)

Collected Data Input	Computed Data Output (Graphical)
Totalized Water Volume Injected Established Steady –state Flow	Injection Flowrate vs Run Time (event, cumulative)
Corresponding Injection Pressure recorded at field manifold.	Injection Gradient vs Run Time (event, cumulative)
Peizometer Levels at Event and Cumulative Time Intervals.	Piezometric Surface Mounding Response vs Time (event, cumulative)
Start Time/End Time/Cumulative Time	Injection Pressure vs Flowrate

Additional data to be obtained to monitor the system performance in advance of proceeding to subsequent operating phases may be obtained. The following key process variables may also be monitored and studied to obtain performance and design information that is required for operation of the process.

- Calendar time (time needed to complete a full cycle of groundwater charging and leveling)
- Run time (time needed to raise groundwater table to return to constant head level)
- Rest time (time needed for groundwater table to return to constant head level)
- Natural rainfall
- Ground water level (using piezometer)
- Cs in groundwater
- spCond of groundwater
- pH of groundwater
- BOD, COD, and TSS (total suspended solids)

Process Flow Diagrams

The Injection Only Process Flow Diagram is presented in Figures 1 and 2 as follows.

FIGURE 1: Process Flow Diagram for Cycles 1 & 2

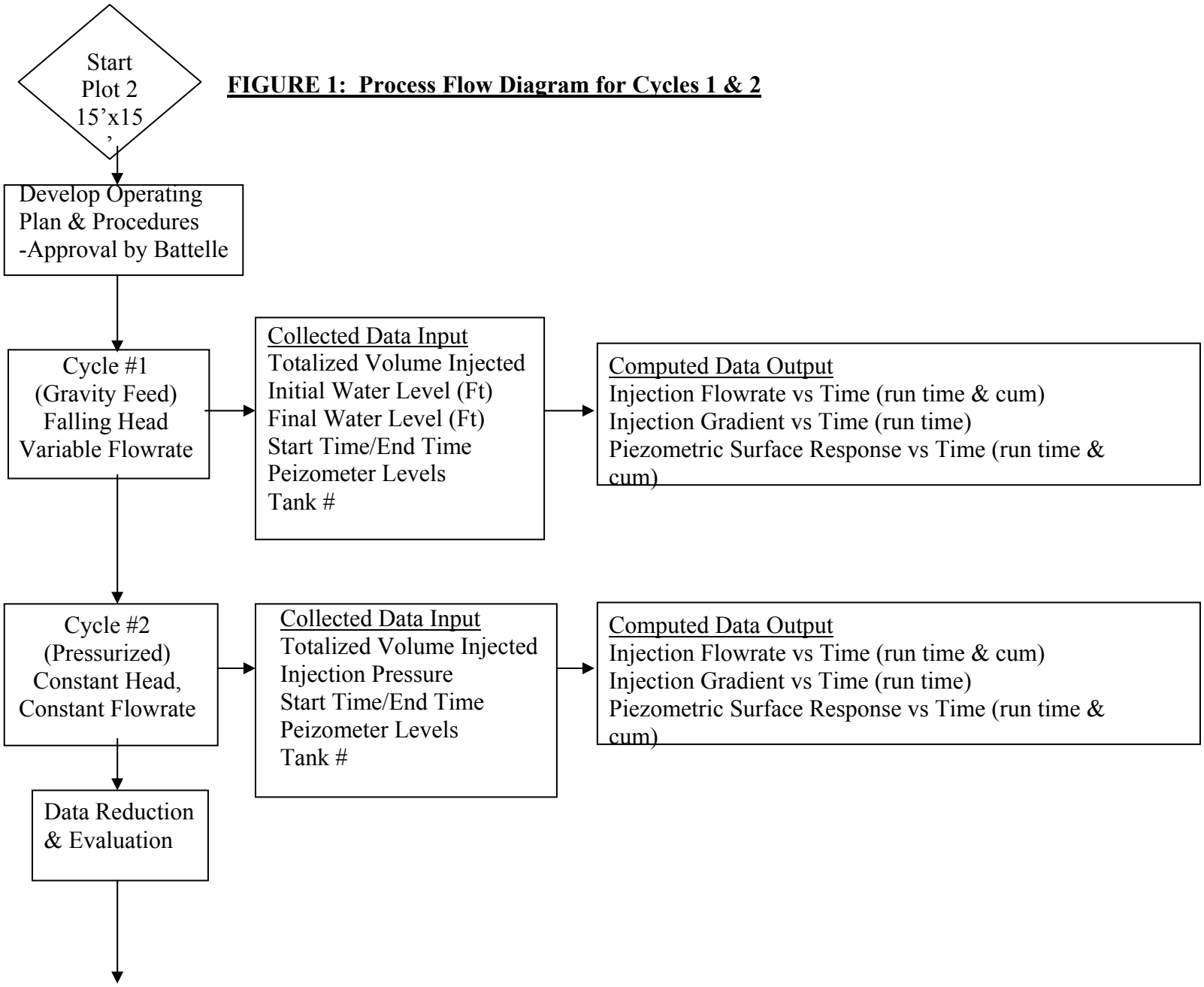
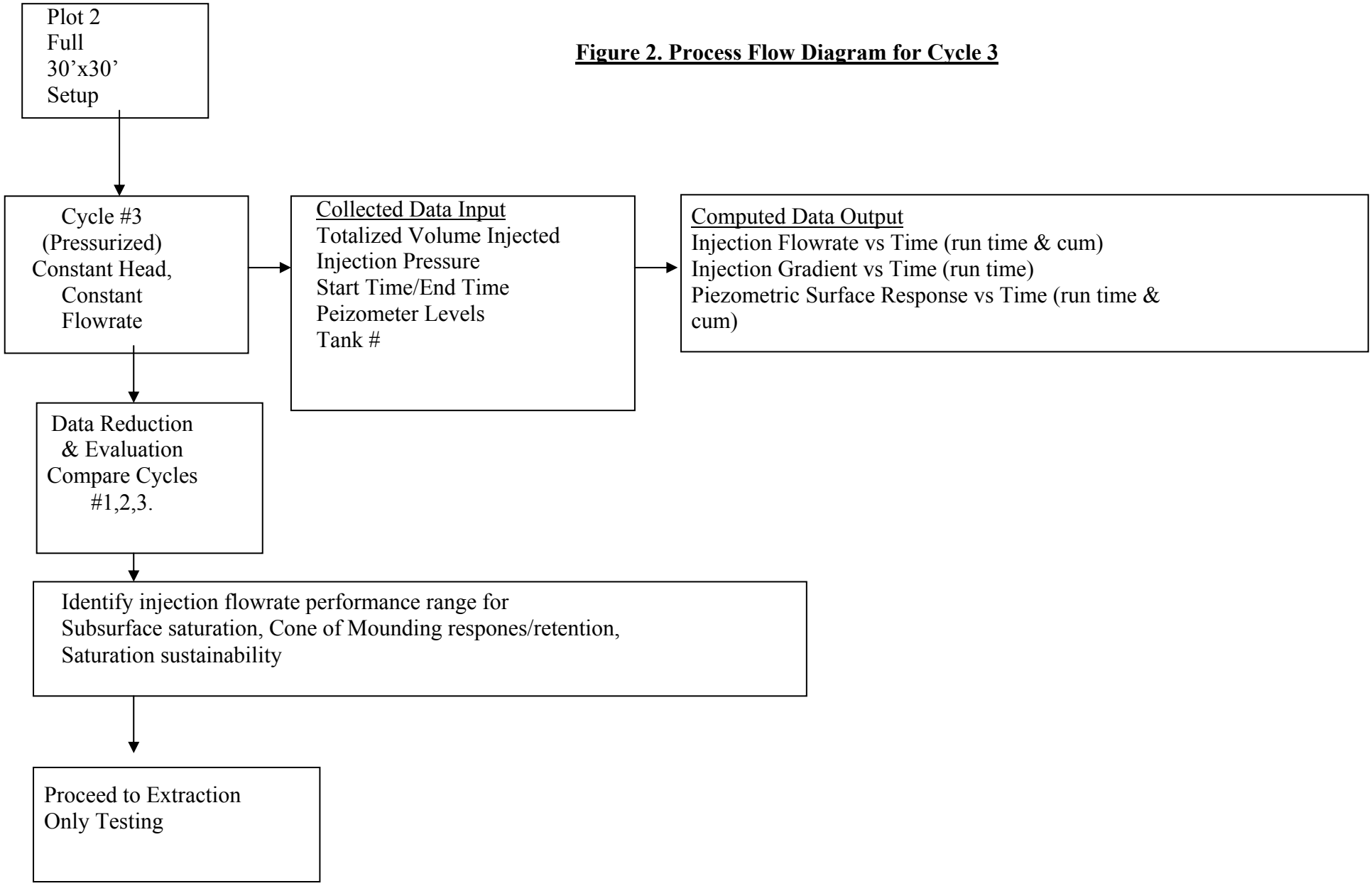


Figure 2. Process Flow Diagram for Cycle 3



SEQUENCE 1: INJECTION ONLY OPERATION, CYCLE 1

Sequence 1, testing Cycle 1 is planned as a three day event.

Days 1-3

Establish initial groundwater piezometric levels.
Record the initial tank water levels.

Time	Activity
7:30 – 8	Obtain Piezometer levels at: P(42,14), P(60,15), P(44,26), P(60,27)
8 – 12	Record Injection Tank Initial Water Level Begin Gravity Injection, Monitor flowrate to achieve desired value. Mark valve position.
8:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
9:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
10:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
11:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
12:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
1:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time
2:30	Obtain Piezometer levels as noted on data sheet. Record Injection tank water level, elapsed time

Sequence 1 Operational Data Sheet, Cycle 1

Injection Test Cycle

Date:_____ Plot:#2 (15'x15')

Target Injection Pressure: Falling Head **Target Injection Volume_____**

Time	*Field Measured* GW Elev (ft) From Top of Casing						Initial Tank Elev. Level (ft)	Final Tank Elev. Level (ft)	Elev. Difference
	P(42,14)	P(60,15)	P(44,26)	P(60,27)	P(44,46)	P(60,45)			

Valve Line-Up Table – Injection Only – Plot 2 (15x15)

Line-Up Position	Valve #			
	Tank #2	**Tank #3**	**Tank #4**	
OPEN	**1076**	**1077**	**1078**	
CLOSED				

SEQUENCE #1 CYCLE #2 COMMISSIONING OPERATIONS

Objective

The objective of a pressurized injection operation on the 15'x15' grid within Plot #2 is to develop a steady-state liquid flowrate distribution through the piping header and manifold assembly to the soil in order to establish a uniform groundwater mound and establish a complete saturation of the subsurface.

Based on results from Sequence #1, Cycle #1, injection on test days #2 and #3 show that flowrates between 100 gal/hr to 250 gal/hr produced similar groundwater mounding responses as reflected by the piezometers. For the pressurized injection cycle, selection of flowrates should pace an approach which will first saturate the soil, then secondly maintain the saturation level within the injection zone, and third produce a mounding front to further saturate the perimeter regions adjoining the one-quarter plot area.

From Day #2, Cycle #1 data, a large volume and rapid injection rate (712 gal/hr) for short duration (0.5 hr) showed a 30 minute advance in saturation as compared with a lower injection rate (270 gal/hr – Day 3) over a 1 hr injection period, even though the cumulative volume injected for the first hour of Day 3 was less than that for Day 2, the piezometer response showed in Day 3 a more sustained saturation period.

This operational protocol is intended to produce initially a uniform mounding profile at the regional piezometers and permit a sustained mounding response maintaining saturation and showing a regional rise in the outlying piezometers.

Establish initial groundwater piezometric levels and continue monitoring during testing at 30 minute intervals as noted in Table 3.

The injection testing under this Cycle is scheduled for a ten day duration. The approach to be employed for this period of Cycle #2 pressurized flowrate follows in Table 2 (a – d).

TABLE 2 (a – d): Projected 15' x 15' Injection Cycle Operation

DAY #1					
Time Period	Flowrate Gal/hr	Duration Hr	Vol. Inj. Gal	Cumulative Vol Inj. (gal)	Response Profile
9:00 am	100	1	100	100	Moderate piezometer mounding response Sustained retention and monitor injection pressures.
10	100	1	100	200	
11	100	1	100	300	
12 pm	100	1	100	400	
1 pm	100	1	100	500	
2 pm	0	0	0	500	Stop Injection, monitor piezometer response
3 pm	0	0	0	500	
3:45 end	0	0	0	500	

DAYS #2 & #3					
Time Period	Flowrate Gal/hr	Duration Hr	Vol. Inj. Gal	Cumulative Vol Inj. (gal)	Response Profile
9:00 am	200	1	200	200	Moderate piezometer mounding response Sustained retention and monitor injection pressures.
10	200	1	200	400	
11	100	1	100	500	
12 pm	100	1	100	600	
1 pm	100	1	100	700	
2 pm	0	0	0	700	Stop Injection, monitor piezometer response
3 pm	0	0	0	700	
3:45 end	0	0	0	700	

DAY #4 & #5					
Time Period	Flowrate Gal/hr	Duration Hr	Vol. Inj. Gal	Cumulative Vol Inj. (gal)	Response Profile
9:00 am	300	1	300	300	Moderate piezometer mounding response Sustained retention and monitor injection pressures.
10	250	1	250	550	
11	200	1	200	750	
12 pm	200	1	200	950	
1 pm	200	1	200	1150	
2 pm	0	0	0	1150	Stop Injection, monitor piezometer response
3 pm	0	0	0	1150	
3:45 end	0	0	0	1150	

DAY #6 through #10					
Time Period	Flowrate Gal/hr	Duration Hr	Vol. Inj. Gal	Cumulative Vol Inj. (gal)	Response Profile
9:00 am	300 (5gpm)	1	300	300	Moderate piezometer mounding response Sustained retention and monitor injection pressures.
10	300 (5gpm)	1	300	600	
11	300 (5gpm)	1	300	900	
12 pm	300 (5gpm)	1	300	1200	
1 pm	0	1	0	1200	
2 pm	0	0	0	1200	Stop Injection, monitor piezometer response
3 pm	0	0	0	1200	
3:45 end	0	0	0	1200	

Valve Line-up Procedure:
Refer to valve line-up configuration as indicated in Table 2.

1) Open valve #5 at injection manifold for Plot #2
2) Open valve #3 at injection line out side NE corner of WIDE building.
3) Open valve # 1078 at Mixing Storage Tank #4, located inside WIDE building.
4) Open valve # 1 at inlet side of injection pump.
5) Open Valve #2, at discharge of injection pump.
6) Power on injection pump and establish pump performance parameters.
7) Monitor pressure gage at discharge side of injection and adjust Valve #2 to set discharge pressure at desired value.

TABLE 2, VALVE LINE-UP		
VALVE #	OPEN	CLOSED
5		
3		
1078		
1		
2		

Field Layout

This testing was limited in Plot 2 to a 15'x15' area as illustrated in Figure 1 below. This zone extended to include approximately 40 Prefabricated Vertical Wells (PVWs) between the boundaries of Row #12, Column 45 to Row #28, Column 60. The twelve piezometers installed within the test area and perimeter areas were periodically monitored during the testing cycles to observe variations in the piezometeric surface.

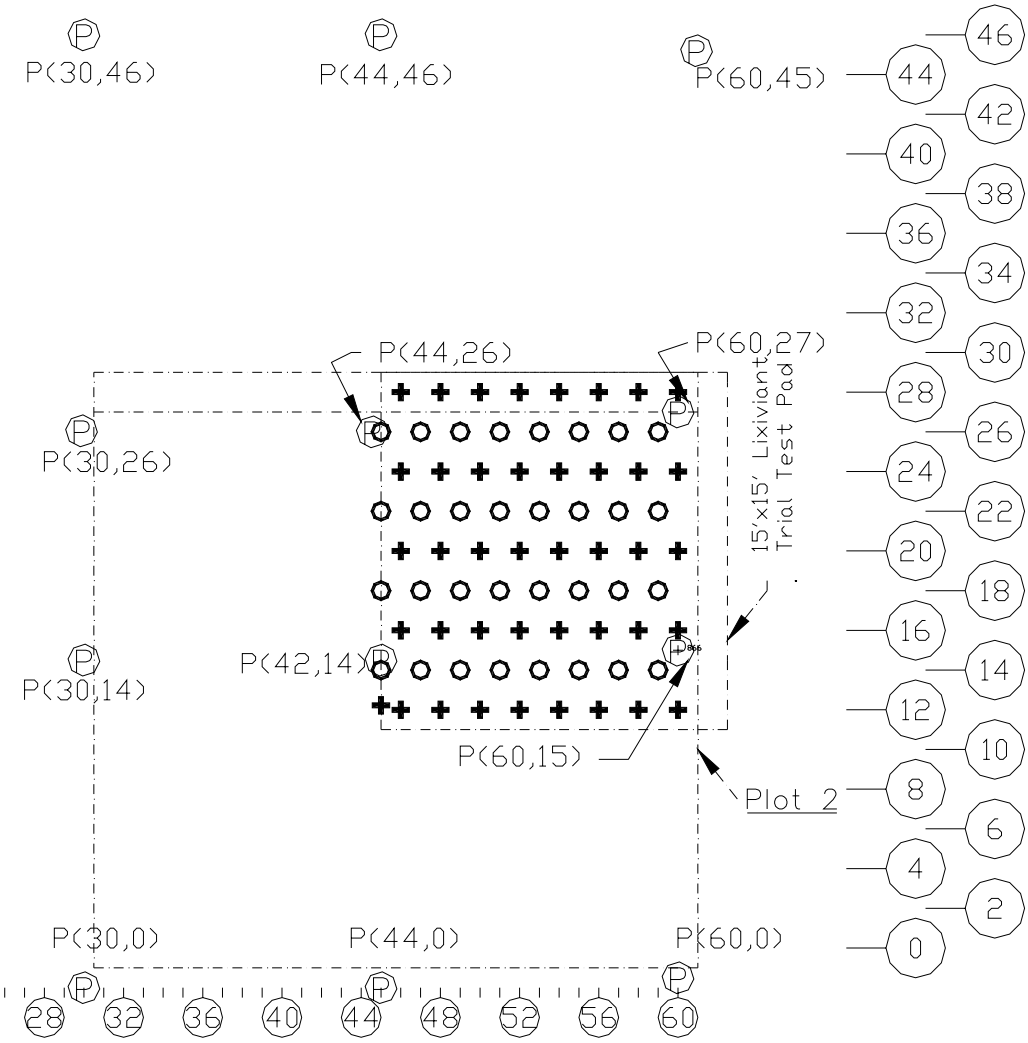


FIGURE #1 : WIDE – PLOT 2

DATA SHEET
Sequence 1 Operational Data Sheet, Cycle 2 Pressurized Injection
Piezometer Head Level

Date:_____ **Plot:#2 (15'x15') Operator:** _____

Target Injection Pressure: 3-4 psi

Time	***PiezometerField Measured* GW Elev (ft) From Top of Casing**												
	P(30,0)	P(44,0)	P(60,0)	P30,14)	P(42,14)	P(60,15)	P(30,26)	P(44,26)	P(60,27)	P(30,46)	P(44,46)	P(60,45)	

Instructions:Record data onto sheet in the order (left to right) that the piezometers are listed.

DATA SHEET
Sequence 1 Operational Data Sheet, Cycle 2
Injection Liquid Parameters

Date:_____ **Plot:#2 (15'x15')**

Date Sequence Number: _____ **Operator:** _____

Batch Volume: _____ **(gallon)(Input Parameter)**

Time Period Start/Stop		Volume Injected (Gallons) (Output)	Flowrate Gal/min. (Output)	Cumulative Total Vol. Injected Gal INITIAL (Output)	Cumulative Total Vol. Injected Gal FINAL (Output)

ACTUAL DAILY OPERATIONS PLAN SHEETS For SEQUENCE #1 CYCLE #2 COMMISSIONING OPERATIONS

WIDE Operation Plan for January 17 to 22, 2003

Friday, 17 Jan

Time	Activity
8:30-9:00	Heat up pumps and valve control header. Replace injector pump drain plug. Verify Hookup flexible distribution injection line. Obtain Piezometer levels at locations indicated on data sheet.
9:00 - 2:00	Input the pump control center the flowrate for the test duration at **700** gallons. Maintain injection rate at or below 6 gallons/minute. Obtain piezometer readings at the start of each hour Record pumping rates/volumes at 30 minute intervals.
2:00 – 3:30	Obtain Piezometer levels as noted on data sheet. Perform liquid drain-down maintenance. Turn off water supply to pump and drain supply lines of water. Startup Air Compressor and allow air pressure to build Disconnect field injection hose and drain Perform a valve lineup to permit the air blow-down of the field collector lines Apply a 10psi air pressure head to the field PVC collector lines and blow-down the four collector lines. Turn down air compressor then shut down, bleed off all compressed air in system reserves. Turn-off building heat
3:30 – 4:00	Fax Data sheets for entire week to Mo Gabr at NC State. (919 515-7908) Put original data sheets in file and place in cabinet.

Monday, 20 January 03 and Tuesday, 21 January 03

Time	Activity
8:30-9:00	Heat up pumps and valve control header. Replace injector pump drain plug. Verify Hookup flexible distribution injection line. Obtain Piezometer levels at locations indicated on data sheet.
9:00 - 2:00	Input the pump control center the flowrate for the test duration at **1150** gallons. Maintain injection rate at or below 6 gallons/minute. Obtain piezometer readings at the start of each hour Record pumping rates/volumes at 30 minute intervals.
2:00 – 3:30	Obtain Piezometer levels as noted on data sheet. Perform liquid drain-down maintenance. Turn off water supply to pump and drain supply lines of water. Startup Air Compressor and allow air pressure to build Disconnect field injection hose and drain Perform a valve lineup to permit the air blow-down of the field collector lines Apply a 10psi air pressure head to the field PVC collector lines and blow-down the four collector lines. Turn down air compressor then shut down, bleed off all compressed air in system reserves. Turn-off building heat
3:30 – 4:00	Fax Data sheets for entire week to Mo Gabr at NC State. (919 515-7908) Put original data sheets in file and place in cabinet.

WIDE Operation Plan for January 21 to 24, 2003

For this week of operation the sub freezing temperature appears to have caused the "injection dedicated" lines to freeze and block the injection water. In order to work around this situation, the injection lines have been changed to use the following configuration:

Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected)

Tuesday, 21 January 2003 through Friday, 24 January

Time	Activity / Procedure
8:30-9:00	Heat up pumps and valve control header. Replace injector pump drain plug. Verify valve supply alignments at supply tanks. Hookup flexible distribution injection line from building header to field manifold. Obtain initial piezometer levels at locations indicated on data sheet;
9:00 - 2:00	Input the pump control center the flowrate for the test duration as follows; {Tue : 750 gal},{Wed 1150 gal}, Thur {1200 gal}, Fri {1200 gal} Maintain injection rate averaging 5 gallons/minute. Obtain piezometer readings at the 30 minute interval for the first two hours and then on the hour for each hour afterwards. Record pumping rates/volumes at one hour intervals.
2:00 – 3:30	Obtain Piezometer levels as noted on data sheet. Record data onto sheet in the order (left to right) that the piezometers are listed Perform liquid drain-down maintenance. Turn off water supply to pump and drain supply lines of water. Startup Air Compressor and allow air pressure to build Disconnect field injection hose and drain Perform a valve lineup to permit the air blow-down of the field collector lines Apply a 10psi air pressure head to the field PVC collector lines and blow-down the collector lines. Turn down air compressor then shut down, bleed off all compressed air in system reserves. Turn-off building heat.
3:30 – 4:00	Fax Data sheets for entire week to Dr. Gabr at NC State. (919 515-7908) Put original data sheets in file and place in cabinet.

WIDE Operation Plan for January 27 to 31, 2003

For this week of operation efforts will be focused on continuing with the following configuration:

Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected)

Based on a review of the field data from 20, 21, and 22 Jan, it appears as though the larger volume of injected water resulted in a groundwater mounding effect which was noticeable in the down-gradient piezometers. Specifically, on 22 Jan the 1100+ gal of water injected resulted in a groundwater mound which extended approximately 30ft down gradient of the test pad area and 15 ft up gradient over the four hour injection period with an injection rate of 5 gpm. The mounding front passed at approximately 2 to 3 hrs after completion of the injection cycle. After several PVWs were re-sealed at the gound/sleeve interface, the surface ponding was minimized.

For this next series of tests the focus will be placed on injection of 1200 gallons at a rate of 5 to 10 gpm. Piezometers will be monitored beginning at each half-hour interval for the first four hours, then on the hour afterwards.

Monday, 27 to Friday 31 January 2003

Time	Activity / Procedure
8:00-9:00	Obtain initial piezometer levels at locations indicated on data sheet;
9:00 - 2:00	Input the pump control center the flowrate for the test duration as follows; {Mon thru Fri : 1200 gal} Maintain injection rate averaging 5-8 gallons/minute. Obtain piezometer readings at the 30 minute interval for the first four hours and then on the hour for each hour afterwards. Record pumping rates/volumes at one hour intervals.
2:00 – 3:30	Obtain Piezometer levels as noted on data sheet. Record data onto sheet in the order (left to right) that the piezometers are listed.
3:30 – 4:00	Fax Data sheets on Wed and Fri to Dr. Gabr at NC State. (919 515-7908) Put original data sheets in file and place in cabinet.

WIDE Operation Plan for February 3 to 7, 2003

For this week of operation efforts will be focused on continuing with the following configuration:

> Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 :
> Total of 40 PVWs (extraction dedicated selected)

Based on a review of the field data from the past two weeks of operation it appears as that there are a difference between injection of water at a low flow rate as compared to a high flow rate.

This series of injection tests into the 15'x15' plot will focus on: a maximum flow during one hour, a pulsed approach using max flow with set interval time steps, and the third approach will be the use of an air curtain in the down-gradient PVW manifold system at Plot 4. These three approaches are expanded on in the following paragraphs:

> 1.) First, injection of 1200 gallons will be made at a pumping rate of 20 gpm over a 1 hour period. Data will be gathered and evaluated for the groundwater mounding response and the resonance time.
> 2.) Second, 2 injection intervals, each of 1200 gallons at a rate of 20 gpm will be performed and at an interval of 3 hours. . Piezometers will be monitored beginning at each half-hour interval for the first two hours, then on the hour afterwards.

Monday, 3 February to Friday 7 Feb 2003

Time	Activity / Procedure
Monday, 3 Feb	
8:00-9:00	Obtain initial piezometer levels at locations indicated on data sheet;
9:00 - 2:00	Inject 1200 gallons at 20 gpm for 1 hour. Obtain piezometer readings at the 30 minute interval for the first two hours and then on the hour for each hour afterwards.
2:00 – 3:30	Obtain Piezometer levels as noted on data sheet. Record data onto sheet in the order (left to right) that the piezometers are listed.
Tuesday, 4 Feb – Wednesday 5 Feb	
8:00-9:00	Obtain initial piezometer levels at locations indicated on data sheet;
9:00- 10:00	Inject 1200 gallons at 20 gpm for 1 hour. Obtain piezometer readings at the 30 minute interval for the first two hours and then on the hour for each hour afterwards.
12:00- 1:00	Inject 1200 gallons at 20 gpm for 1 hour. Obtain piezometer readings at the 30 minute interval for the first two hours and then on the hour for each hour afterwards
3:30	Record final data and fax data sheets to NCSU.

Thur, 6 February 2003; 10:00 am
11 February 2003; 2:30

Thursday, 6 February 2003 & Monday 10, Tues 11 February 2003	
Time	Event
8:00 – 8:30	Record Piezometer levels Start Air Compressor and let it come to operating level.
8:30-9:30	Inject 1200 gallons at 20 gpm Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected)
8:30 – 3:30	Apply a **4-7** psi injection air pressure head to Plot 4, Column/Row Lines #: Rows 30, 34, 38, 42 at Columns 30 to 60. Apply vacuum consistently during both water injection cycles. **Turn injection air pressure OFF when taking Piezometer readings**.
8:30 – 3:30	Record Piezometer levels at 30 minute intervals for first 2 hours after each injection period, then hourly afterwards.
11:30-12:30	Inject 1200 gallons at 20 gpm Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected)
3:30	Perform blow-down of injection lines. Shut-down operation for the day.

11 February 2003; 2:30 pm

Wednesday, 12 February 2003 & Thursday, 13 February 2003	
Time	Event
8:00 – 8:30	Record Piezometer levels Start Air Compressor and let it come to operating level.
8:30-9:30	Inject 1200 gallons at 20 gpm Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected) Record Piezometer levels at 30 minute intervals for first 2 hours after each injection period, then hourly concurrent with the air injection cycle.
9:30-10:30	Only record piezometers.
10:30-12:30	Apply a **4** psi injection air pressure head to Plot 4, Column/Row Lines #: Rows 30, 34, 38, 42 at Columns 30 to 60. **Turn injection air pressure OFF when taking Piezometer readings**.
11:30-12:30	Inject 1200 gallons at 20 gpm Column/Row Lines Engaged: Rows 12, 16, 20, 24, 28; Col 46 to 60 : Total of 40 PVWs (extraction dedicated selected)
	Record Piezometer levels at 30 minute intervals for first 2 hours after each injection period, then hourly concurrent with the air injection cycle. Perform blow-down of injection lines.
12:30-1:00	Only record piezometers.
1:30 – 3:00	Apply a **4** psi injection air pressure head to Plot 4, Column/Row Lines #: Rows 30, 34, 38, 42 at Columns 30 to 60. **Turn injection air pressure OFF when taking Piezometer readings**.
3:00-3:30	Final Piezometer reading. Perform winter shut-down activities. End for Day